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Characteristic properties of materials for evaporative patterns

Z. Żółkiewicz*, M. Żółkiewicz
Foundry Research Institute, Zakopiańska Str. 73, 31-418 Kraków, Poland
* Corresponding author. E-mail adress: kzs@iod.krakow.pl

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Abstract

To complete the cast models including EPS process the use of different materials such as polystyrene, copolymer, others. One of the main parameters affecting the flow of metal in the mold of the gasification kinetics model.
In studies described in this article, attention has been focussed on the determination of gas volume emitted from evaporative patterns of predetermined density. Two variables were used, i.e. the type of material for evaporative patterns and temperature. The effect of pattern evaporation temperature on the emitted gas volume was investigated. Tests were carried out on samples representing various materials. In this part of the article, the gas evolution rate at temperatures of up to 400^{o}C was discussed. The obtained results were depicted in graphical form

Keywords : casting, pattern, foamed polystyrene pattern, temperature, gas

1. Guidelines for research

1.1. Material for pattern tooling (patterns, dies)

The following materials were used for the evaporative patterns:
Polystyrene (PS) (-[$CH_2CH(C_6H_5)$] manufactured by styrene polimerisation, usually originating from the process of petrol refining. The most popular application of polystyrene is in the manufacture of one of its variations, called **foamed polystyrene**. Foamed polystyrene is produced by rapid steam heating of polystyrene in the form of granules, inside which a small volume of the foaming agent is present. It is a mixture of n-pentane and iso-pentane. In foundry industry, foamed polystyrene is used in the manufacture of evaporative patterns.
Copolymer – a type of polymer, the chains of which include mers of two or more different types. Contrary to copolymers, polymers contain only mers of one type, and as such are often called *homopolymers*. The main reason why copolymers are produced is a unique set of the physical properties they possess and which homopolymers cannot offer although they contain the same mers.

As typical examples of the statistical copolymers, in which the mers are scattered at random along the chains, can serve the following materials: SAN (styrene-acrylonitrile) and ABS (acrylonitrile-butadiene-styrene). The latter one, while being easy in moulding, offer also a very high tensile strength and high impact resistance. ABS is an artificial thermoplastic material characterised by high mechanical properties. It is used in the manufacture of prototype pattern tooling made by RPS directly from an electronic documentation.
The selected properties of ABS copolymer (according to specification made by STRATASYS who manufacture this material) are as follows:

- Tensile strength Type 1, 0,125 22,06 MPa
- Elongation Type 1, 0,125 6%
- Modulus of linear elasticity Type 1, 0,125 16727,16 MPa
- Shear modulus 1834 MPa
- Bending strength 41,31 MP
- Specific gravity 1,05

- Hardness R105
- Izod impact resistance (notched) 106,78,73 J/m
- Izod impact resistance (unnotched) 213,561 J/m
- Deformation temperature 76 (91) ° C
- Glass transition temperature 104 ° C
- Melting point; in natural amorphous condition this material never reaches its melting point

Dies used for the manufacture of evaporative patterns are made from the material designated as PPSF (polyphenylsulphone), which is resistant to the effect of chemical agents. In the family of plastic materials, it is characterised by a relatively high thermal and mechanical resistance, combined with high dimensional accuracy. It is used for automotive, medical and aircraft applications; recently, the range of its applications has been extended to include also foundry patterns made by RPS technique. The selected properties of PPSF (according to specification made by STRATASYS who manufacture this material) are as follows :

- Tensile strength 55 MPa
- Elongation 3%
- Softening point 189 ° C
- Glass transition temperature 230 ° C
- Specific gravity 1,28
- Hardness M86
- Impact resistance (notched) 58,73 J/m
- Impact resistance (unnotched) 165,51 J/m

1.2. Measurement of gas evolution rate from the evaporative pattern materials

In present investigations, attention was focussed on the determination of gas volume emitted from the following pattern materials: XZ1, Xz2, XZ3 and PS polystyrene. The emitted gas volume was measured using the available devices of modified design, which measure the volume of emitted gas in neutral atmosphere and at preset temperature. The variable was temperature kept in a range of 200°C to 1200°C. The effect of temperature on the emitted gas volume and pattern evaporation rate was determined.
Selected relationships showing the emitted gas volume in function of evaporation temperature (200 °C to 400 °C) are shown in Figures 3, 5, 7, 8.

Fig. 1. Apparatus for the measurement of emitted gas volume

The gas volume V emitted from XZ1 pattern
Evaporation temperature 200°C
Specimen weight 0,5g,
Emitted gas volume V = 0 cm^3
Evaporation temperature 400°C
Specimen weight 0,5g,
Emitted gas volume V = 4cm^3

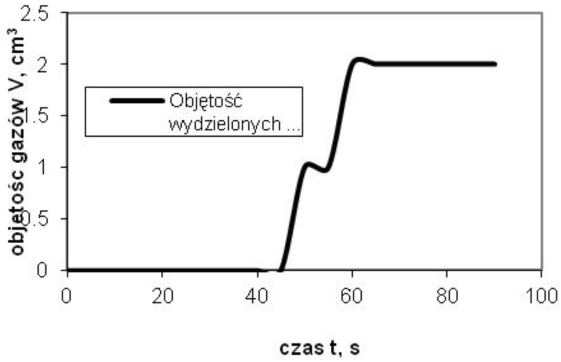

Fig. 2. Volume V of gas emitted from XZ1 pattern weighing 0,25g at 400°C, cm^3

Fig. 3. XZ1 pattern evaporated at 400°C; note changes in pattern configuration

Volume V of gas emitted from XZ2 pattern

Fig. 4. XZ2 pattern

Evaporation temperature 200°C
Specimen weight 0,5g,
Emitted gas volume after 6 min. V=12 cm^3
Q of emitted gas=12 cm^3/g
Evaporation temperature 400°C
Specimen weight 0,5g,
Emitted gas volume V =42cm^3 Q of emitted gas =42 cm^3/g

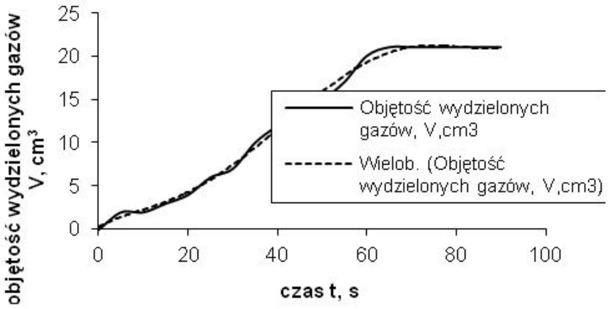

Fig. 5. Volume V of gas emitted from XZ2 pattern weighing 0,5g at 400°C, cm^3

Volume V of gas emitted from XZ3 pattern
Evaporation temperature 200°C
Specimen weight 0,5g,
Emitted gas volume after 6 min V=12 cm^3
Q of emitted gas =12 cm^3/g

Evaporation temperature 400°C
Specimen weight 0,5g,
Emitted gas volume V =40cm^3
Q of emitted gas =40 cm^3/g

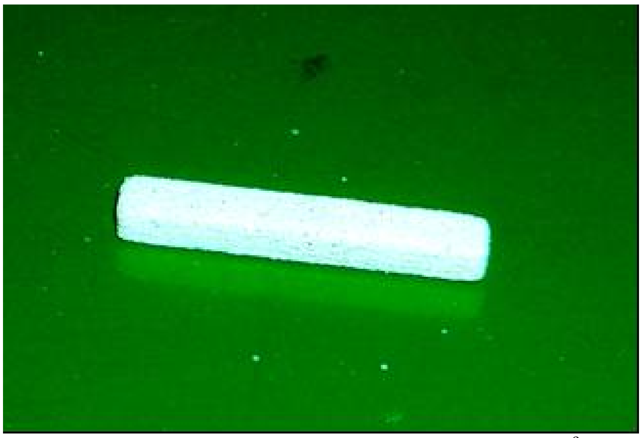

Fig. 6. XZ3 pattern evaporated at temperatures from 200°C to 1000°C

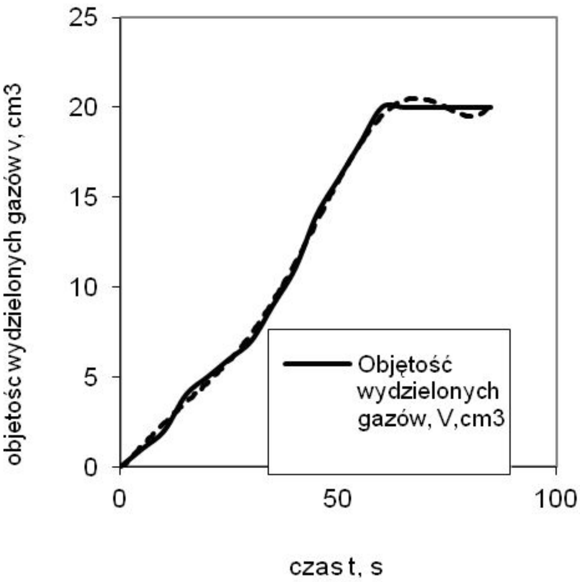

Fig. 7. Volume V of gas emitted from XZ3 pattern weighing 0,5g at a temperature of 400°C, cm^3

Volume V of gas emitted from polystyrene (PS) pattern

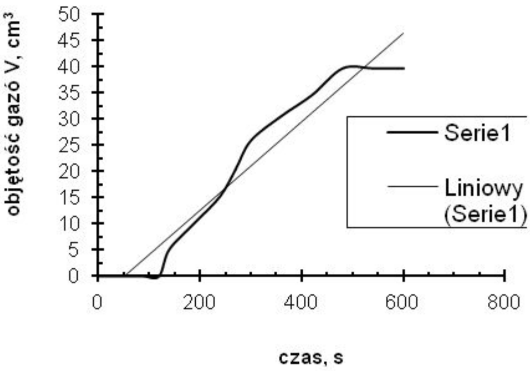

Fig. 8. Gas volume emitted from polystyrene pattern weighing 1 g at 400°C in function of time (polystyrene pattern material of 20 kg/m^3 density) – series 1

2. Conclusions

The investigations were focussed on quantitative evaluation of gas emission rate from the examined materials. Because of proprietary composition of these materials, especially of XZ, the quantitative chemical analysis was not given. The composition has been reserved by the manufacturer.

The emitted gas volume depends on the type of material used for evaporative pattern and on the evaporation temperature. An increase of temperature increases the emitted gas volume. The higher is the temperature, the larger is the volume of the emitted gas, and the shorter is the time of pattern evaporation. The highest gas emission rate has the PS polystyrene, followed by XZ1; the lowest rate offers XZ. With temperature increase, the time of pattern thermal decomposition is shorter, while the emitted gas volume and gas expenditure are higher.

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